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Range Cattle Production, 6

MATERNAL FACTORS

A Literature Review

By

C. B. ROUBICEK, R. T. CLARK and O. F. PAHNISH

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CATTLE PRODUCTION

A Literature Review

Section VI

MATERNAL FACTORS

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CATTLE PRODUCTION

MATERNAL FACTORS

Cow Fertility

The productivity of a cow is measured by her ability to wean a healthy, heavy calf each year. The problems associated with fertility are complex and include an interaction of genetic, nutritional, environmental, and management factors. These same factors are involved in prenatal and postnatal development of the calf.

The importance of percentage calf crop and weaning weight of the calves in economical beef production has been presented on a dollar basis (227).

If the total annual cost for each cow is $100, the cost per hundred pounds of weaned calf, depending on the percent calf crop and the weaned weight of the calf will be:

Percent Calf Crop	Average Weaned Weight of Calf (lbs.)	Cost of Calf Per Cwt.
100	600	$16.67
	500	20.00
	400	25.00
80	600	20.83
	500	25.00
	400	31.25
60	600	27.78
	500	33.33
	400	41.67

The production cost for a range operator can be computed from the formula:

> Death loss (percent) times value of cow equals death loss cost plus running cost per unit equals carrying cost per unit plus bull cost per cow equals cow maintenance cost divided by calf crop percent equals cost of calf at three months of age (42).

The cost per calf increases 10 percent for each 10 percent reduction in percentage calf crop (112).

The causes of sterility in cattle have been classified as (a) congenital or hereditary factors, including malformations and underdevelopment of the sexual organs as well as a predisposition to endocrine disorders, (b) acquired or environmental factors, including disease and infection, and (c) malnutrition (160).

An important factor in accurately determining female fertility is embryonic death loss. A general review of prenatal death as a factor in fertility indicates a death rate of 30 percent in the first 90 days (54). Although there may be considerable variation between herds, experimental evidence indicates clearly that embryonic death loss may be a major consideration in measures of cow fertility (48)(61)(128)(231)(232). A factor contributed by the male resulting in early embryonic mortality also has been reported (8)(218). It has been estimated that approximately 40 percent of all potential young in dairy cattle are lost 60 to 90 days after breeding (128). Although accurate data on embryonic mortality will be very difficult to obtain for range cattle, it still must be included as a consideration in range cattle fertility studies.

Genetic and Endocrine Factors in Infertility

A form of sterility characterized by a developmental deficiency called "white heifer disease" is considered as an inherited condition (6)(38)(91)(207). The term is nondescriptive, although it has been reported most frequently in white heifers of the Shorthorn breed. Other types of inherited sterility also have been reported in the Jersey, Fresian, Swedish Highland and other breeds of cattle (8)(70)(80)(91)(95)(96)(97)(105)(129)(160)(161)(162)(223).

It is probable that the endocrine system is involved in almost every infertility problem. The so-called "freemartin" is a classical example of a direct endocrine effect on reproduction (252). Hormones have been used extensively in an attempt to improve fertility in cattle, but in general the practical use of hormones for therapy is limited and results are uncertain (111)(115). The thyroid is involved in general fertility, at least as it directly affects metabolism and growth (206). The adrenal and pituitary have been shown to have direct effects on at least certain phases of reproduction (62)(237). Levels of hormone production, or at least the activity of the endocrine glands, have been shown to be influenced to a large extent by the animal's genotype. Inheritance, then, becomes an important consideration in improving beef cattle fertility.

Fertility as Affected by Herd Management

The peak in calf production is reached with 6- to 7-year-old cows (47)(151)(164). There is a tendency for cows to repeat their breeding performance. A record of the breeding performance over a period of two years should be sufficient for the elimination of poor breeding cows (13)(164).

Crossbred females have higher calf crop percentages than straight-bred animals (131)(198).

Sexual maturity is delayed if animals are restricted in food intake (181)(204). Inadequate nutrition affects reproduction, although it may not always be possible to determine if it is due to a specific deficiency or general undernutrition (98)(160)(199).

The quantitative and qualitative requirements for reproduction do not exceed those for growth of young animals or those for adequate maintenance of mature animals (204). The difficulty of determining the exact role of nutrition in infertility is shown by the analysis of careful records kept in England (77). These records over a number of years have shown large differences between adjacent areas on farms. Changes occur in the relative fertility of farms and areas without any apparent reason. These changes, called "waves of fertility" also have been noted in the United States (71). The correlation between breeding efficiency for consecutive years was 0.084. Only 9.3 percent of the "problem herds" were problem herds the next year. It has been stated that the nutrition of the dam during pregnancy is of secondary importance to climate and other environmental factors (255). It also has been noted that there is a striking difference in the age at sexual maturity of heifers born in different years (201). This difference cannot be explained as all heifers were kept under similar conditions from year to year. The influence of rainfall was not significant, neither could hereditary influence be proved. There is a definite season effect on fertility, with cattle of various ages responding differently and consistently to seasons (182). Younger and older cattle appear to be influenced more readily by season and nutritional level than are mature animals (118)(123)(182). Adaptability of animals to a particular environment appears to be very important (35).

Phosphorus and protein appear to be possible nutritional deficiencies in many of the range areas. Of the mineral elements generally considered essential to animal life, phosphorus is most likely to be incriminated in reproductive trouble (7)(79)(171)(186)(199). The fact that a phosphorus deficiency causes a decreased appetite and consequent inanation also may be important (98).

The addition of a phosphorus supplement, especially under southwest range conditions, has resulted in a marked increase in percentage calf crop (31)(76)(112)(146)(150)(208)(242). It appears that an inorganic phosphorus level of 3 to 4.5 milligrams per 100 cc. of blood plasma may be optimum for mature range cows in the southwest region (32)(146). This level can be maintained with a daily phosphorus intake of 10 to 12 grams (146)(188). Animals on low phosphorus and low protein diet appear to be more seriously affected than if on low protein alone (113). Both protein and phosphorus are deficient in range plants during the winter months (83)(146).

Although there are many manifestations of vitamin A deficiency, under range conditions the symptoms are usually considered as reproductive failure (99). It has been suggested that the carotene blood-plasma level of first-calf range heifers must be at least 117 micrograms per 100 ml. for normal reproduction (194). Values for range cows are apparently much less (172). A long-range study of vitamin A supplementation on dormant New Mexico ranges has indicated that a vitamin A deficiency would likely occur only in case of prolonged drouth or extremely abnormal conditions (244)(245).

The feasibility of breeding yearling heifers to calve as two-year-olds is of considerable interest. It has been estimated that under range conditions only about 65 percent of the yearling heifers will become pregnant (21). It also has been estimated that 25 to 60 percent of the heifers require help at calving although three-year-old heifers may not be particularly different (56)(57)(197). In a record of 2,545 heifer calvings, about 2 percent of the heifers died while calving (1). The size of the heifers at calving is important. The heifers should be well grown out by calving time (1)(21).

TABLE I

Relation of Weight of Heifers to Calving Performance (57)

	Weight of Heifers at Breeding		
	Over 500 lbs.	450-500 lbs.	Below 450 lbs.
No. of heifers requiring help	5	8	9
No. of heifers calving normally	12	7	5

It has been recommended that, in order to obtain near maximum production, range heifers should weigh about 650 pounds at 20 months of age, with 600 pounds as a practical minimum standard (145). It also has been observed that heifers having a heavy yearling weight calved as two-year-olds more frequently than did heifers with a light yearling weight. In subsequent years, dams which were large as yearlings tended to calve later than those which were small as yearlings. Because of this, selection for heavier yearlings would tend to give lower, rather than higher, actual yearling weights in offspring when the dams are allowed to breed as yearlings (116).

It also appears that the individuality of the bull is more important than the breed of the bull (57). It is suggested that young, small-bodied, small-boned bulls be used (1). If the heifers are fed for continuous growth, the age of first calving has no permanent influence on the ultimate size of the animal (21)(123).

TABLE II

Influence of Breed of Bull on Calving Performance of Two-Year-Old Hereford Heifers (56)

Summary of Results at Stillwater, Oklahoma

	Breed of Bull: Hereford		Angus	
Sex of calf	M	F	M	F
No. calves born	9	11	14	8
Average birth weight	64	63	60	55
No. calves pulled	2	4	5	0
Calves lost at calving	2	1	0	0
Cows lost at calving	1	1	0	0

Summary of Results at Amarillo, Texas

	Breed of Bull: Hereford		Angus	
Sex of calf	M	F	M	F
No. of calves	75	55	63	44
Average birth weight	61	58	61	56
No. calves pulled	50	32	43	19
No. calves lost	10	3	12	4
No. cows lost	3	2	3	0

Delayed breeding with a consequent noninterruption of sexual cycles over a period of years led to some of the following difficulties (168):

(a) Increased number of services for conception.
(b) Parturition frequently complicated by dystocia and followed by stillbirths, retained placenta, and agalactia.
(c) An increased incidence of abortion.

Birth and Weaning Weight in Cow Production

Cows with longer gestation produce calves heavier at birth (40)(49)(50)(212). Age of dam has been reported to influence birth weight of the calf, with heaviest calves from cows 6 to 8 years of age (40)(66)(133)(239)(257).

TABLE III

Effect of Age of Cow on Weaning Weight of Calves (133)

Age of Cow	Ave. Weaning Weight
2	347
3	360
4	370
5	375
6	377
7	373
8	365
9	355
10	347
11	325

Since weight and age of cow are closely associated, it may not always be possible to accurately separate the effects. When comparisons are made between types of cattle, significant differences are apparent (151)(257).

There were no significant differences in either the birth or weaning weights of the heifer calves from full- and limited-fed cows of large or small type. However, when all of the calves, steers, and heifers from three-year-old cows only were considered, significant differences were determined. Calves from the full-fed three-year-old cows were significantly heavier at birth and made larger daily gains than did those from three-year-old, limited-fed cows. After this age, the influence of the ration was not apparent in either birth weights or in the average daily gains of the calves from birth to weaning. This would indicate that the effect of the low maintenance ration fed to the heifers was not permanent and therefore had no sustained influence on the size of the calves from the full- and limited-fed cows in the years subsequent to the discontinuance of the two levels of feeding (257).

TABLE IV

Average Birth and Weaning Weights of Heifer Calves (257)

Calves From	Small Type Cows Full-Fed		Large Type Cows Full-Fed		Small Type Cows Limited-Fed		Large Type Cows Limited-Fed	
	No. of head	Av. wt. in lbs.	No. of head	Av. wt. in lbs.	No. of head	Av. wt. in lbs.	No. of head	Av. wt. in lbs.
Birth weights	41	66.2	36	73.9	40	65.1	49	71.4
Weaning weights	41	371.7	36	400.1	40	381.0	50	407.3

TABLE V

Comparison of Weights of Large- and Small-Type Cows (257)

	Small Type Cows Full-Fed		Large Type Cows Full-Fed		Small Type Cows Limited-Fed		Large Type Cows Limited-Fed	
	No. of head	Av. wt. in lbs.	No. of head	Av. wt. in lbs.	No. of head	Av. wt. in lbs.	No. of head	Av. wt. in lbs.
Yearlings	65	722.4	62	784.4	61	681.6	66	726.7
2-year-olds	58	1000.6	53	1066.8	57	945.9	63	992.4
3-year-olds	46	1037.6	33	1084.4	47	960.7	41	1009.0
4-year-olds	31	1071.8	24	1120.5	29	1052.9	19	1054.7
5-year-olds	21	1120.2	15	1185.4	24	1092.7	13	1092.8
6-year-olds	18	1150.7	8	1207.3	19	1109.5	12	1141.9
7-year-olds	11	1170.5	5	1223.2	16	1153.1	5	1183.4

TABLE VI

Average Birth Weight of All Calves from Cows Included in Type Experiment: Type of Dam and Ration Fed (257)

Age of Dam	Small Type Full-Fed No. of Head	Small Type Full-Fed Av. Wt. in Lbs.	Large Type Full-Fed No. of Head	Large Type Full-Fed Av. Wt. in Lbs.	Small Type Limited-Fed No. of Head	Small Type Limited-Fed Av. Wt. in Lbs.	Large Type Limited-Fed No. of Head	Large Type Limited-Fed Av. Wt. in Lbs.
3 years	48	69.3	36	78.4	48	66.3	47	70.1
4 years	36	66.3	35	77.2	35	68.7	29	74.8
5 years	27	72.9	16	78.9	29	70.0	22	75.2
6 years	23	72.1	15	79.3	23	70.8	16	77.3
7 years	13	75.5	10	77.6	19	75.3	11	77.7
Average		70.2		78.1		69.3		73.7

TABLE VII

Average Daily Gain from Birth to Weaning of All Calves from Cows Included in Experiment: Type of Dam and Ration Fed (257)

Age of Dam	Small Type Full-Fed No. of Head	Small Type Full-Fed Av. Daily Gain in Lbs.	Large Type Full-Fed No. of Head	Large Type Full-Fed Av. Daily Gain in Lbs.	Small Type Limited-Fed No. of Head	Small Type Limited-Fed Av. Daily Gain in Lbs.	Large Type Limited-Fed No. of Head	Large Type Limited-Fed Av. Daily Gain in Lbs.
3 years	47	1.51	34	1.75	48	1.45	44	1.61
4 years	34	1.51	32	1.71	34	1.59	28	1.68
5 years	28	1.59	15	1.71	28	1.77	20	1.73
6 years	21	1.59	14	1.79	22	1.61	16	1.86
7 years	12	1.77	9	1.84	19	1.77	11	1.90
Average		1.56		1.75		1.57		1.71

TABLE VIII

Weight of Cows at Different Ages and Weight of Calves Produced (147)

Age of Cows (yrs.)	Average Weight of Cows (lbs.)	Average Weaning Weight of Calves (lbs.)
3	908	387
4	952	405
5	983	429
6	1013	447
7	1024	454
8	1017	450
9	993	436
10	981	422

Crossbreeding

In the subtropical regions, Zebu x British breed crosses consistently have resulted in higher calf production. Results from Australia indicate 25 to 50 percent Zebu blood as optimum (125).

TABLE IX

Weaning Weights of Calves Resulting from Polyallele Crossing (211)

Breeding of Sire	Breeding of Dam	Calf Weaning Weight (6 months)
Angus	Angus	325
Zebu	Angus	398
Africander	Angus	379
Zebu x Africander	Angus	386

TABLE X

Birth and Weaning Performance of Calves in Subtropical Climates (210)

Breeding	Number	Calf Data Birth Weight	6-Month Weight
Hereford sire x Hereford cows	56	75	316
Brahman x Hereford	55	75	354
Hereford x (Brahman x Hereford)	59	76	402
(Hereford x Brahman) x Hereford	37	83	390

TABLE XI

Average Weights of Females from Birth to 6 Years of Age (11)

Breeding	Birth No.	Birth Wt.	6-Month No.	6-Month Wt.	1 Year No.	1 Year Wt.	2 Years No.	2 Years Wt.	4 Years No.	4 Years Wt.	6 Years No.	6 Years Wt.
Purebred Angus	27	56	27	293	18	435	16	698	7	850	9	911
Brahman x Angus	56	66	56	350	50	561	47	766	22	1012	18	1048
Angus x (Brahman x Angus)	54	62	54	392	51	603	46	766	20	895	18	983
(Brahman x Angus) x Angus	42	63	42	353	39	551	38	738	14	896	7	969
(Brahman x Angus) x (Brahman x Angus)	21	62	21	375	14	520	9	732	-	-	-	-
Africander x Angus	31	64	31	350	28	528	28	725	12	933	7	1038
(Africander x Angus) x (Africander x Angus)	15	64	15	322	14	503	14	694	2	918	-	-

TABLE XII

Weaning Weights of Hereford and Brahman x Hereford Calves (170)

Sire	Dam	Weaning Weight
Hereford	Hereford	373
Brahman	Hereford	383
Hereford	Brahman x Hereford	449

An experiment is under way in southern United States to determine the relative performance of various breed crosses.

The design of the experiment is such that 20 different types of crossbred calves and 4 types of purebred calves are produced in the first phase. Six herds of 32 cows each, composed of 8 Angus, 8 Brahman, 8 Brahman-Angus, and 8 Hereford cows, were bred to bulls of six different breeds. Bulls from the Angus, Brahman, Brahman-Angus, Charolaise, Hereford, and Shorthorn breeds were used. A new bull is selected each year to represent each breed, and the herds are bred to a different breed of bull each year (64).

180-Day Weights of Calves Sired by Bulls of Six Breeds

Breed of Bull	No. of Calves Weaned	Av. 180-Day Weight
Angus	43	399
Brahman	30	417
Brahman-Angus	29	399
Charolaise	40	450
Hereford	42	434
Shorthorn	28	436

180-Day Weights of Calves Produced by Four Breeds of Cows

Breed of Cow	No. of Calves Weaned	Av. 180-Day Weight
Angus	51	408
Brahman	51	438
Brahman-Angus	60	437
Hereford	50	406

Average 180-Day Weights for Top-Ranked Crosses

Breeding of Calves	180-Day Weight	Rank
Shorthorn x Brahman	512	1
Charolaise x Brahman	483	2
Shorthorn x Brahman-Angus	456	3
Charolaise x Brahman-Angus	456	4
Hereford x Brahman-Angus	454	5
Charolaise x Angus	446	6
Hereford x Brahman	445	7
Brahman x Brahman-Angus	440	8
Angus x Brahman	433	9
Hereford	428	10

The consistent results shown by crossbreeding in the southern areas are not confined to Zebu breeding (126). In Oregon, however, Brahman x Hereford crossbred calves did not gain as well as Hereford calves, especially during severe winters (119). In Montana, Hereford x Shorthorn crossbreds did show an advantage over Hereford calves (131).

TABLE XIII

Comparison of Hereford and Hereford x Shorthorn Heifers (14)

	Advantage of Crossbred Heifers	
	Pounds	Percent
Birth weight	3.00	
Weaning weight	20.20	
18-month weight	51.00	
30-month weight	87.9	
Body score as yearling		4.0

In a comparison of Hereford and Angus cows and their reciprocal crosses, it was shown that the relative performance of the calves depended to a large extent on the breed of the dam (87)(88).

Nutrition

The amounts of nutrients necessary to develop the bovine fetus are so small that they cannot be measured by ordinary methods (73). The nutrition of the cow does not have an appreciable influence on the birth weight of the calf (74). The level of wintering beef cows does not have a consistent effect on birth or weaning weight of the calves (29)(197)(238).

TABLE XIV

The Effect of Age at First Calving and Level of Winter Feeding Upon the Performance of Beef Cows (197)

	Lot Number							
	1	2	3	4	5	6	7	8
No. of cows at start of experiment	15	15	15	15	15	15	15	15
Ave. initial cow wt.	477	480	477	486	470	485	479	489
Ave. final wt.	993	1061	1075	1116	1084	1067	1121	1130
No. calves dropped	40	40	38	41	29	27	28	28
No. calves weaned	39	40	35	38	28	27	25	24
Heifers assisted first calving	6	8	4	10	0	0	1	0
Ave. birth wt.	71	70	72	70	72	70	71	68
Ave. weaning wt.	435	437	433	448	461	448	460	456

Lots 1 and 2	- 1.0 lb. cottonseed cake per head daily.
Lots 3, 4, 7, and 8	- 2.5 lbs. cottonseed cake per head daily.
Lots 5 and 6	- 2.5 lbs. cottonseed cake and 3.0 lbs. oats per head daily.
Heifers of lots 1, 3, 5, and 7	- Bred as yearlings.
Heifers of lots 2, 4, 6, and 8	- Bred as 2-year-olds.

Under conditions of environmental stress, chronic undernourishment can be detected even in the newborn calves of unadapted types (35).

TABLE XV

Relative Performance of Beef Cows Wintered on the Range With and Without a Supplement of Cottonseed Cake (29)

Item	Group 1	Group 2
Cows in group	276	266
Winter range period		
Ave. initial wt. per cow	1,103	1,099
Ave. gain or loss per cow	+22.9	-10.9
Cottonseed cake consumed per cow	90.7	-
Summer range period		
Ave. loss per cow	42.	21.
Winter and summer period		
Ave. loss per cow	19	32
Calf production		
Calves weaned	235	229
Calf crop	85	86
Ave. birth weight	76	74
Ave. weaning weight	372	359
Ave. age at weaning	178	179

Group 1 . . . . on range and fed cottonseed cake.
Group 2 . . . . on range and fed no supplement.

Cottonseed cake is a valuable supplement on native range but for greatest economy its use should be limited to seasons in which winter range conditions are severe.

Phosphorus supplementation of cows on the range appears to be of value in increasing calf production and improving the general health of animals.

TABLE XVI

Effects of Phosphorus Supplement on Cattle Grazing on Range Deficient in this Mineral (31)

	Control	Treated
Calf crop	64%	85%
Calves weaned	58%	81%
Cows calving 2 consecutive years	30%	73%
Weaning weight	426 lbs.	495 lbs.

TABLE XVII

Comparison of Supplying Phosphorus to Range Cattle (32)

	Calf Crop			
Control Group	1	2	3	4
Calf crop (percent)	91	88	74	22
Calves weaned (percent)	86	83	67	22
Ave. weaning wt. (lbs.)	500	500	460	497
Treated				
Calf crop (percent)	98	98	95	95
Calves weaned (percent)	93	95	88	92
Ave. weaning wt. (lbs.)	529	533	519	590

TABLE XVIII

Effect of Mineral Supplements on Weight and Production of Range Cattle (150)(151)

Measure of Production	Cows Not Fed Minerals	Cows Fed Minerals	Gain from Mineral Feeding
Cows calving (percent)	90.4	92.2	1.8
Calves died (percent)	10.8	2.7	8.1
Cows weaning calves (percent)	80.7	89.7	9.0
Average weight of calves (lbs.)	408	442	34
Gain of yearling steers (lbs.)	321	353	32
Gain of 2-year-old heifers (lbs.)	202	278	76

To prevent phosphorus deficiency, the minimum amount of inorganic phosphorus in the blood of cattle should be above 4 mg. per 100 cc. of whole blood (32). Good results were obtained with average inorganic blood plasma phosphorus level varying from 2.11 mg. during the winter to the high of 5.37 mg. during the summer and fall months (243).

There are indications that in certain areas copper and cobalt may be deficient (4). Cobalt requirements are met with about 0.1 ppm. of cobalt in the feed, or an intake of about 1.0 mg. daily by adult cattle (4)(20). Studies with radio-calcium indicated age and nutritional status of animals to be major factors influencing the physiological behavior of calcium. Pregnancy and stage of gestation, dwarfism, source of dietary calcium, and current calcium intake were of less effect (108).

Levels of soluble fluoride in the diet can be tolerated as high as 1 mg. per kilogram of body weight over periods as long as from 5 to 10 years, with no detectable effect except possible slight mottling and slight wear of incisor teeth. A level of soluble fluoride in the diet in the order of 2 mg. per kilogram of body weight per day may result in mottling and severe wear of incisor teeth that form during the period of ingestion, as well as lameness and stiffness, emaciation, and general unthriftiness.

It was concluded that fluorine content of urine must be well above 10 parts per million to indicate current consumption of fluorine in damaging amounts (203).

TABLE XIX

Mineral Requirement for Cattle on Basis of Dry Ration (183)

Mineral	
Calcium	.3 percent
Phosphorus	.2 percent
Potassium	-
Magnesium	.07 percent
Manganese	-
Iron	25 to 50 ppm.
Copper	3 ppm.
Cobalt	.07 ppm.

In very early growth, about 0.04 pound of phosphorus is required for each pound of protein required. In the fully grown animal, the ratio drops to 0.02 pound or less of phosphorus per pound of protein. Feeding excess amounts of mineral (above requirements) shows no advantage for range cattle (149). Range beef cattle require more minerals in the winter than in the summer (221). Mineral consumption also was significantly higher on heavily grazed pasture.

Self-Feeding Salt-Meal Mixtures

The practice of self-feeding a mixture of salt and protein supplement to range cattle is a common practice in the southwest area. For 400-pound weaner calves, 1 pound of salt to 4 pounds of meal maintained daily meal consumption at 2 pounds. At a ratio of 1 part salt to 2 parts meal the animals consumed 1 pound of meal per day (221). Range cows will eat 2 to 3 pounds daily of a 30:70 salt-meal mixture (52)(214). If adequate water is available, there are no apparent adverse effects of the abnormally high salt consumption (52)(189)(214)(220)(221). A digestion trial actually indicated a beneficial effect of the high salt intake upon digestibility of all nutrients, particularly protein, crude fiber and nitrogen-free extract (214). Digestible cellulose, as well as digestible gross energy, are not altered by the increased consumption of salt (51). A mixture of 25 percent salt and 75 percent cottonseed meal was consumed by sheep from October 1 to March 1. The average daily intake of salt per ewe ranged from .058 pound to .116 pound. There was no apparent effect of the salt consumption on lamb production, wool production, and ewe weights (249). In a study of the effect of saline and alkaline waters on domestic animals it was found that the inability to suckle young was noted before any injury to the mother was apparent (114). Sodium chloride was somewhat less active than calcium chloride, and magnesium chloride was most injurious. Blood analysis did not show any marked changes. There is also a recent indication which suggests that cows fed salt-meal might be lower than average in fertility (177).

Vitamin A

Beef cows receiving a carotene allowance equivalent to 60 micrograms per pound of body weight daily were unable to maintain liver stores or plasma vitamin A levels during the last 6 months of gestation. When the carotene allowance was increased to 333 µg. during lactation, liver stores and plasma vitamin A were increased (15)(16).

Vitamin A in the plasma and liver of the calf was closely associated with the carotene intake of the dam during lactation, but was also influenced by the liver stores of the cow at parturition.

TABLE XX

Average Vitamin A and Carotene Content of Livers of Cows and Their Calves (mcg./gm. dry matter)(18)

Liver Component	Lot No.	5 Mo. Prepartum	At Parturition	3 Mo. Postpartum
Vitamin A	I	302.9	141.3	31.4
	II	307.6	138.4	111.4
	III	151.2	56.3	9.7
	IV	251.7	112.3	84.0
Carotene	I	20.2	4.7	2.5
	II	18.7	5.3	11.1
	III	11.6	5.7	1.8
	IV	17.3	6.9	9.8
Calves				
Vitamin A	I		3.9	3.3
	II		5.7	15.9
	III		2.7	1.7
	IV		2.9	13.5

TABLE XXI

Average Vitamin A and Carotene Content of Plasma and Milk of Cows and Vitamin A Content of Plasma of Calves (mcg./100 ml.)(18)

Item	Lot No.	5 Mo. Prepartum	1 Mo. Prepartum	At Parturition	Lactation 1 Wk.	Lactation 2 Wk.	Lactation 1 Mo.	Lactation 2 Mo.	Lactation 3 Mo.
Plasma	I	32.5	25.0	17.3	14.4	17.0	17.2	18.6	15.5
Vitamin A	II	30.0	21.1	12.2	14.3	17.9	15.6	15.4	26.5
	III	27.4	20.9	13.4	12.2	12.6	12.5	12.1	16.9
	IV	34.0	25.5	16.8	12.3	17.1	19.6	22.8	30.4
Plasma	I	111.6	22.9	21.3	19.8	21.2	20.8	18.4	18.6
Carotene	II	102.9	21.6	17.5	89.4	127.5	147.9	149.1	151.7
	III	73.8	41.4	48.1	28.1	26.9	23.3	17.2	19.5
	IV	97.5	49.1	63.0	89.6	113.2	101.1	117.0	92.3
Milk and	I			144.0	6.2	5.3	6.2	6.3	3.8
Colostrum	II			224.5	11.0	7.8	9.0	8.8	8.6
Vitamin A	III			128.3	6.5	5.7	3.8	3.7	3.3
	IV			133.2	10.0	7.8	7.6	6.6	7.2
Calves	I			4.9	13.2	11.6	7.9	6.0	4.5
Plasma	II			3.8	12.0	11.5	9.5	9.0	12.6
Vitamin A	III			6.2	8.6	7.3	5.9	4.6	5.6
	IV			4.9	13.6	13.8	10.3	10.0	11.5

The vitamin A and carotene content of milk appears to be more closely related to dietary carotene intake during lactation than to liver stores (18). The daily minimum carotene requirement of cattle has been stated as 26 to 33 micrograms per kilogram live weight (100). The critical level of carotene in plasma has been considered as about 25 micrograms per 100 ml. vitamin A at about 16 micrograms per 100 ml. (65). Studies of vitamin A supplementation on New Mexico ranges indicate that a vitamin A deficiency might occur only in case of prolonged drought or extreme abnormal conditions which would probably necessitate the removal of livestock or full scale feeding operations (244)(245)(247). Similar results were obtained in Canada (174).

The accumulation of vitamin A in the body tends to increase with age and is dependent on the character of the diet. Yearlings on a definite vitamin A deficient diet required 128 to 266 days to show deficiency symptoms (213). Seasonal declines of plasma vitamin A and carotene may occur for periods without the clinical symptoms of avitaminosis (236). It has been suggested that when dehydrated alfalfa is used as a supplement, the protein supplementation may be a more critical factor than vitamin A (240). There does appear to be decreased vitamin A storage in the liver and increased plasma levels for animals on a phosphorus deficient diet (84).

Creep Feeding

Under conditions of feed shortage on the range or if it appears desirable to wean the calves of two-year-old heifers at an early age, there may be a need for creep feeding calves.

Sixty-two Angus and Hereford calves were weaned at 90 or 180 days and fed individually until 370 days of age. Heifers weaned at 90 days of age were lighter in weight at 180 days than those weaned later but were of similar weight at one year of age. The average gain per 28-day feeding period was much more uniform for the 90-day group (93).

Present indications are that 90-day weaning does not adversely affect beef calves, and perhaps an earlier evaluation of rate of gain is possible by early weaning.

TABLE XXII

Pounds of Total Digestible Nutrients Required Daily by Beef Calves to Maintain Weight and Make Regular Daily Gains (254)

Weight of animal	To Maintain Weight	TDN Required (Pounds) 1/2 Lb.	3/4 Lb.	1 Lb.	1-1/2 Lbs.	2 Lbs.
200	1.9	2.6	3.0	3.4	4.2	-
300	2.5	3.5	4.0	4.5	5.5	6.5
400	3.0	4.2	4.8	5.4	6.6	7.8
500	3.5	4.9	5.6	6.3	7.7	9.1

Shelled corn, oats and cottonseed pellets are considered good feeds in creep feeding (122). Conditions of drouth or heavy stocking may penalize the daily gain of suckling calves as much as a pound a day during certain periods (260). These calves still suffered from the effects of this setback at 12 and 18 months of age.

It has been estimated that about 10 pounds of milk are required to make a pound of gain (250).

In a study of Hereford, Angus, and Shorthorn cows, samples of milk and butterfat production were obtained during a two-day period each month by one-half of the udder one day and the other half the following day. Beef cows between the ages of two and three years produced less milk than cows of any other age studied. The quantity of milk produced had a tendency to increase up to six years. Maximum milk and butterfat production on the average was obtained during the first month of lactation. The lactation curve declined beginning with the first month and continued at an ever-decreasing rate until the end of lactation. This study gave some evidence that the physiological processes of milk secretion in beef cows are limited to the capacity of the calves to consume milk (89).

TABLE XXIII

Correlation Between Quantity of Milk Produced Daily by the Dams and Daily Gain in Weight of Their Calves (89)

Month	r
1	+.60
2	+.71
3	+.52
4	+.35

Cows which maintain a higher condition throughout the periods of gestation, lactation, and rest, are likely to produce calves which are small and light in weight (200).

Range Studies

In a summary of experimental work at the Great Plains Station, Woodward, Oklahoma, several guides are suggested for use in determining proper grazing of a range (177). A stubble height of at least 1 inch should be left on short grasses. Midgrasses should have a minimum stubble height of at least 2 inches at the close of the grazing season, tall grasses 3 to 5 inches. Ten to 20 percent of the seedstocks of better grasses should be left unused. There should be no evidence of small new gullies or sheet erosion which causes hummocking of individual grass clumps. Animals should not be forced to eat large quantities of coarse or unpalatable forage. Brush should not be badly broken apart by grazing animals looking for forage. Proper stocking rates vary as much as 100 percent between good and poor years.

TABLE XXIV

Relative Grazing Capacity of Range Land in Relation to Average Annual Precipitation (60)

Average Annual Precipitation (inches)	Grazing Capacity for Range in Good Condition (acres)	Approximate Average Grazing Capacity of Large Areas (acres)
0-5	60-200	-
5-10	35-80	200 or more
10-15	25-45	70-200
15-20	12-35	40-120
20-25	8-15	15-40
25-30	3-12	10-40
over 30		3-20

Grazing capacity = number of acres required to support a cow for a year.

It has been noted that there is a marked effect of season and periods within season on gain. In general, low gains were made when vegetation was poorly developed because of spring cold or drought and also when vegetation made unusually rank growth, poor quality resulting (229).

Protein has been found deficient for range animals in 2 percent of samples of young range grass and in 73 percent of the mature samples (83).

Phosphoric acid was sufficient in almost all young grasses but deficient in almost all mature grasses.

TABLE XXV

Long-time Trend in Grass Value and Steer Gains (177)

Grass Nutrients	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Oct.
Protein (percent)	4.4	3.5	3.4	3.0	3.5	18.0	12.4	8.1	5.6	4.7	5.2
Phosphorus (percent)	.10	.10	.08	.07	.10	.34	.25	.21	.16	.16	.14
Calcium (percent)	.44	.34	.29	.35	.41	.45	.40	.38	.39	.33	.41
Carotene (ppm.)	17	-	3	-	13	449	236	-	111	-	71
Steer gains:											
Av. daily gain (lbs.)	.0	.6	.6	.5	.6	1.3	2.0	2.0	1.8	1.4	1.0

It has been estimated that the minimum calcium requirement for beef cattle is 0.23 percent of dry matter of range forage, phosphorus is 0.13 percent of dry matter of forage (219). Crude fiber represents about one-third of the average composition of dry range grasses and varies inversely with the more valuable chemical constituents of the forage.

Steers wintered on different planes of nutrition tend to equalize in weight the following summer. Under the same conditions, steers which made low winter gains also made the lowest summer and yearling gains (177).

The more cows gained in weight in the winter, the more they lost in weight, or failed to gain, the following summer. Cows that lost weight during the winter or made very small gains lost proportionately less or actually gained weight the following summer (239).

In a study of raising heifers in the mountain meadow areas, it was determined that the daily consumption of hay per animal is relatively constant, regardless of the quality of the hay (251). The use of nitrogen and phosphorus fertilizers did not affect the feeding value of the hay significantly, but there was a direct relationship between pounds of crude protein available daily in the ration and the rate of animal gain.

Range Grass Sampling

Range samples collected for analysis do not always represent the feed consumed by livestock, neither as to proportion of each species eaten nor as to selected parts of each plant (179). Although grasses may analyze almost identical, there are marked differences in their ability to promote gain in cattle. Livestock prefer a variety of diet.

In seasons of high temperature, animals seemed to adjust themselves to seasonal variations by changing the proportions of different food nutrients ingested (185).

Indicators have been used in an attempt to determine the amount of dry matter intake by grazing animals. The lignin ratio technique has proved to be sufficiently accurate in determining feed intake and digestibility (78)(82)(233). The chromogen-chromium oxide method for determining dry matter intake also gives only satisfactory results (39)(109). These studies indicate that the digestibility of pasture forage dropped as forage matured. The trend of herbage intake paralleled the pattern of digestibility (39). The size of growing steers influences the amount of herbage consumed.

It has been determined that 80 percent of the food residues is excreted between 70 and 80 hours after ingestion (3).

In estimating cattle diet by herbage sampling techniques, a list of plant groups and a record of plant parts eaten compose the necessary records. Estimates of the contribution of individual species to cattle diet are difficult to obtain and are of little importance in the light of the forage analysis. Species ratio estimates may vary considerably within a class or group of plants without being accompanied by changes in the chemical composition of the forage (102).

Grazing Behavior

Apparently, continuous observations are not necessary. Recording the animal activity at 4-minute intervals gives sufficiently precise results (110)(120).

The most constant periods of grazing during the 24 hours occur in early morning, and in late afternoon until dusk. The commencement of early morning grazing is correlated to sunrise, and the cessation of evening grazing to sunset (120). Between these two primary periods no definite pattern could be recognized in the daytime.

Although there was considerable variation between animals, the average time spent was:

Grazing	-	7.9 hours
Ruminating	-	7.8 hours
Idling	-	9.3 hours

Grazing time was only slightly in excess of ruminating time in midsummer. In the spring and autumn, grazing time exceeded ruminating time by 100 percent. It is suggested that these differences are the result of changes in quantity and quality of herbage. In a series of studies with monozygotic cattle twins, the following results were noted (104)(106)(107):

(a) Cattle prefer to graze in daylight and it is only when the hours of light in the temperate zone become very short, or where the day temperatures are too high for comfort, that cattle spend an appreciable part of their grazing time in darkness.

(b) If the quantity of pasture offered to cattle is ample, grazing times are long if mixed grasses are present, intermediate if quality is good, and short when quality is poor.

(c) Individual, inherent peculiarities in regard to the size of each bite and the number of bites per minute, or in regard to the ability to utilize the consumed food, must be of some importance.

(d) Beef cows walk 5,800 yards per day on free range, 2,400 on 5-acre pasture.

(e) Cows deficate 11-16 times per day. Cows urinate 9-12 times per day.

(f) Grazing times are significantly shorter in the middle of the summer when the fiber content of the grass is high than either in spring or autumn when the fiber content is much lower.

(g) Rumination times are markedly influenced by inherent factors.

(h) From 60-70 bites per minute were counted at the beginning of each grazing cycle, falling to from 40-50 at the end.

(i) Variations in the distances which cows walked appear to be hereditary.

(j) Variations in the number of times cows drink in a day are largely genetically-determined.

(k) There is variability in grazing behavior due to external and internal conditions. In a temperate zone, climate is relatively unimportant.

(l) Quantity and quality of herbage are important in determining grazing time.

(m) Ruminating time is strongly dependent on quantity and quality of ingested grass.

(n) Adaptation of grazing habits to new conditions is very rapid.

(o) Twin sets graze and ruminate at a characteristic rate.

Studies of Zebu cattle showed the following grazing pattern (110):

Grazing	-	7 to 8 hours
Ruminating	-	4-1/2 to 6 hours

Ninety percent of the grazing was in daylight; 23 percent of the ruminating was in daylight.

Records were kept of the grazing habits of cattle in a mixed-prairie pasture (184). The study was conducted from April 1 through September 20. Studies were generally restricted to the herd rather than to individual animals. At least one day of each week, every hour from 8:00 A.M., to 8:00 P.M., notes and counts were made as to the location and activities of the cattle. A record was made of the number grazing, standing idle, lying down, ruminating, drinking, and licking salt. In addition, on two occasions the herd as a group and certain individual animals were closely observed for a 24-hour period.

The grazing areas varied during the season, depending on the green feed available.

Grazing began between 5:00 and 6:00 A.M., depending on the time of sunrise, and continued unabated for about 3 hours. The cattle then started moving toward water, doing some grazing along the way. After reaching water, some drank immediately while others ruminated a short time, either standing or lying down. The middle part of the day was marked by alternate periods of resting and feeding during the first part of the summer, but by a distinct resting period in late summer. The evening grazing period was well under way by 5:00 P.M., and lasted until 8:00 P.M., or later when the cattle bedded down. During the active grazing periods, the herd tended to become scattered in small groups which joined into one or two herds during the idle periods.

Heritability Estimates, Repeatability, and Correlations of Cow Production Factors

Reproduction

Heritability

Item	Heritability	Reference
Services per conception	.026	(167)
Calving interval	0	(167)
Nonreturns to first service	.004	(72)
Calving interval	0	(45)

Cow Repeatability

Item	Repeatability	Reference
Services per conception	0	(167)
Calving interval	.133	(167)
Nonreturns to first service	.027	(72)
Calving interval	0	(45)
Birth weight	0 to 25	(226)
Time to first estrus following parturition	0 to .27	(53)
Time from first breeding to conception	0 to .08	(53)
Number of services to conception	0 to .08	(53)

Correlations

Number of services for conception/milk production. $r = -.04$ (37)

Milk Production

Heritability

Item	Heritability	Reference
Milk production	.142 to .284	(261)(262)
Butterfat production	.245 to .368	(261)(262)
Milk production	.32 to .39	(121)
Percentage butterfat	.54 to .68	(121)

Item	Heritability	Reference
Milk Production		
Repeatability		
Milk yield	.41 to .43	(121)
Percentage butterfat	.59 to .64	(121)
Correlations		
Milk yield/body length	+.59	(224)
Butterfat/body length	+.03	(224)
Butterfat/body width	+.07	(224)
Milk yield/width lower jaw	-.82	(224)
Daily milk production/week of lactation	+.33	(193)

There is a possible negative correlation between milk production of dam and gain of progeny in the feedlot (140).

There is a decrease of 73 pounds of milk and 2.3 pounds of butterfat for 1 percent increase in inbreeding (235).

There is no relationship between relative hypophysis weight and producing ability (92).

Item	Heritability	Reference
Weight and Gain		
Heritability		
12-month weight	.647	(46)
Repeatability		
Weaning weight	.43 to .49	(36)
Gain birth to weaning	.38	(36)
Weaning weight	.52	(152)
Weaning weight	.21 to .61	(226)
Gain birth to 4 months	.34	(216)
Weaning weight	.50	(94)
Correlations		
Daily milk production/ave. daily gain of calf	r = +.44	(193)
Week of lactation/ave. daily gain of calf	r = -.50	(193)
18-month weight of dam/weaning weight of calf	r = 0.10	(176)
Weaning weight of adjacent calves	r = .25 to .62	(226)

A regression of .95 increase in weaning weight of calf per one percent increase in inbreeding of the dam (176).

Inbreeding less than 0.20 does not cause decrease in body size at any state of development (173). Females inbred over 0.20 develop normally to approximately first calving age, but show markedly abnormal development thereafter.

The following is a correlation of a cow's last calf with the best calf she ever produced:

$$r = +.33 \ (67)$$

Conformation

TABLE XXVI

Repeatability of Live Animal and Photographic Measurements (225)

	Repeatability	
Factor	Live Animal Measurement	Photographic Measurement
Length of body	.546 to .898	.726 to .844
Height at withers	.888 to .906	.908 to .927
Depth of chest	.784 to .914	.807 to .908

The agreement between judges is relatively low, generally between .4 and .7. The repeatability of a judge's scores of the same cow in different seasons was generally between .4 and .6. Forty to 50 percent of the variation between judges was due to differences between cows, leaving the remaining variation due to other factors.

Influence of age on the scores of cows showed a downward trend in the average scores of animals for about 2-1/2 years after the first scoring. Later the average scores went up and tended to be similar to the calf score. Fifteen to 30 percent of the variation in cattle scores was due to the interaction of judges and cows and seasons, and to random errors in scoring (44).

Estimates of Repeatability

Weaning Score	Repeatability	Reference
Intra-class correlation	.04 to .39	(226)
Correlation of adjacent calves	.09 to .28	(226)
Condition Score		
Intra-class correlation	.04 to .51	(226)
Correlation of adjacent calves	.19 to .45	(226)

Inbreeding has no effect on type score (176).

Selection for Cow Production

TABLE XXVII

The Repeatability of the Yearly Production of Range Cows (156)

	Weight	Grade
One year's calf with next	.49	.25
First year's calf and		
1. Second	.66	.24
2. Ave. of 2nd and 3rd	.53	.39
3. Ave. of 2nd, 3rd, and 4th	.51	.40
4. Ave. of 2nd, 3rd, 4th, and 5th	.53	.42
Average of first 2 calves and		
1. Third	.54	.46
2. Ave. of 3rd and 4th	.55	.60
3. Ave. of 3rd, 4th, and 5th	.59	.69

TABLE XXVIII

Weight of Calves Produced by 3-Year-Olds Compared to Average Weight of Their Next Four Calves (153)

Group	Calves in Group (percent)	Ave. Wt. of First Calf (pounds)	Ave. Wt. of Next Four (pounds)
I	8	321	404
II	22	349	417
III	37	383	430
IV	23	409	443
V	10	441	456

TABLE XXIX

Average Effect of Pregnancy on Live Weight (19)

No. Days Before Calving	No. Days After Service	Pregnant Live Wt. if Wt. After Calving is Considered 100
282	0	100.00
272	10	100.00
262	20	100.00
252	30	100.00
242	40	100.00
232	50	100.00
222	60	100.05
212	70	100.15
202	80	100.30
192	90	100.50
182	100	100.75
172	110	101.05
162	120	101.40
152	130	101.80
142	140	102.25
132	150	102.75
122	160	103.30
112	170	103.90
102	180	104.55
92	190	105.25
82	200	106.00
72	210	106.80
62	220	107.65
52	230	108.55
42	240	109.50
32	250	110.50
22	260	111.55
12	270	112.65
3	279	113.75
0	282	113.75

Records show that cows are quite consistent in the weights of the calves they produce. Those with calves below average one year will usually produce another lightweight calf the next time, even though they may take one year's rest (228).

If cows were separated into high- and low-producing groups, it was found that subsequent calves from high-producing group produced calves 31 pounds heavier than low-producing group (55).

In general then, it may be concluded that considerable progress can be made in selecting breeding cows on the basis of the first calf record.

A suggested selection procedure is as follows (67):

(a) Retain a high percentage of heifers for one or two calf crops and select those which demonstrate their ability to wean heavy calves for further use in the herd.

(b) Select sires from among the sons of cows which have repeatedly demonstrated their ability to wean heavy calves and which are the grandsons of bulls whose daughters have on the average produced heavy calves at weaning.

(c) Where possible, use sires whose daughters have proved to have good maternal abilities.

There is also a definite tendency for cows to repeat their breeding performance. A record of breeding performance over a period of two years should be sufficient for the elimination of poor breeding cows (13)(164).

TABLE XXX

Effects of Selection for Certain Traits in the Parents on Related Traits in the Offspring (33)

Basis of Selection	Average Superiority of Both Parents	Related Trait in Offspring	Estimated Change
Weaning weight	20 lbs.	Weaning grade	Minus 0.2 units
Weaning weight	20 lbs.	Yearling weight	Plus 6 lbs.
Weaning weight	20 lbs.	Yearling grade	Minus 0.2 units
Weaning weight	20 lbs.	Yearling gain	Plus 10 lbs.
Weaning grade	1 unit	Yearling weight	Minus 20 lbs.
Weaning grade	1 unit	Yearling grade	Plus 0.4 units
Weaning grade	1 unit	Yearling gain	Minus 6 lbs.

The genes that control growth at one period are probably the same, or include a portion of the same, genes which influence growth at a later period (217)(253).

Heifers having a heavy yearling weight calved as 2-year-olds more frequently than did heifers with a light yearling weight. In subsequent years, dams which were large as yearlings tended to calve later than those which were small as yearlings. Because of this, selection for heavier yearlings would tend to give lower, rather than higher, actual yearling weights in offspring when dams are allowed to breed as yearlings (116).

TABLE XXXI

Physiologically Equivalent Ages and Body Weights (101)

Beef Cattle	Percent of Mature Weight 10	20	30	40	50	60	100
Average age (mos.)	1.0	3.5	5.5	8.0	11.0	14.6	72
Average weight (lbs.)	130	260	390	520	650	780	1300

A comparison was made of the conformation, anatomy, and skeletal structure of a highly specialized dairy cow and a highly specialized beef cow (230).

In external form the two cows differed greatly. In weight and size of internal organs, the differences were not sufficiently great to indicate significant differences in function.

In skeleton structure the two cows varied somewhat but were generally similar. This would indicate that the evolution of the dairy and beef types, which has been accomplished through breeding and selection, has not materially altered their skeletal structure, but rather that the difference in type is due to extreme fleshing on the one hand and to udder devel pment and absence of fleshing on the other.

Aside from the external form, the most marked differences noted between the cows compared was the quantity of secretory tissue in their udders.

In a study of classification scores of Hereford cows, it was found that judges were able to agree more closely with one another on a particular date than they were able to agree with their previous scores. Although significant differences in judges' scores existed, they were of minor importance in determining the total variance in conformation scores.

Seasonal differences in scoring level and the interaction of cows with season were important sources of variation in these data, indicating a need for more careful consideration of temporary environmental conditions in the evaluation of our beef animals (90).

It also was noted that there is a downward trend in the scores from calfhood until roughly the age of first lactation, after which the scores tend to increase up to about 5-1/2 years. After this, scores remain about constant until changes associated with senility begin to cause a decline (43).

A black dye (Nyanzol) may be used for identification of animals. The dye is good for the life of the hair coat. One pound of dye should brand 750 head of cattle (222).

Directions for mixing Nyanzol:

A. Materials
   1. Nyanzol dye
   2. Gum arabic
   3. Hydrogen peroxide

B. Dissolve 6 heaping teaspoonfuls of powdered Nyanzol dye in a cupful of boiling water.

C. Dissolve 6 heaping teaspoonfuls of gum arabic in a cupful of cold water.

D. After the two are dissolved, mix them together and place in a tightly covered container.

E. Before using the dye add 1/2 cupful of hydrogen peroxide to the mixture.

If numbers are to be used, they should be at least 6 inches high and 4 inches wide. Use 1/4-inch rods wrapped with felt.

Chemical Analysis

Blood:

Plasma and blood volume for non-pregnant, non-lactating cows (208):

Plasma - 35 to 40 cc. per kg. body weight
Blood - 49.6 to 60.6 cc. per kg. body weight

Bovine plasma and blood volumes per unit weight are significantly lower than those for rats, rabbits, dogs, sheep, and man.

TABLE XXXII

Vitamin A Blood Plasma Values in Cows and Calves on Deficient and Adequate Vitamin A Ration (16)

	Vitamin A (µg./100 ml.) Deficient Ration	Adequate Ration
Cows:		
Plasma, at calving	11.32	16.30
Plasma, 2-week lactation	11.1	17.7
Plasma, 3-month lactation	13.3	23.5
Milk, at calving	45.56	90.56
Milk, 2-week lactation	4.9	7.7
Milk, 3-month lactation	2.8	4.5
Calves:		
Plasma, at birth	3.06	4.13
Plasma, 2 weeks	6.19	14.40
Plasma, 3 months	4.10	11.90

Cows (187):
Carotene, µg./100 ml. plasma: 115-1088
Vitamin A, µg./100 ml. plasma: 12.5-38.2

Cows, 7-day postpartum (127)
Vitamin A, µg./100 ml. plasma: 10.5

Vitamin A and Carotene Content of the Blood of Pregnant Cows (18)

Item	5 Months Prepartum	1 Month Prepartum	At Parturition
Cows:			
Plasma Vitamin A	32.5	25.0	17.0
Plasma carotene	111.6	22.9	21.3

Carotenes, µg./100 ml. plasma: 340 to 500 (85).
Xanthophylls, µg./100 ml. plasma: 5.8 to 45.0 (85).

Plasma carotene was affected by season, but was not greatly different in cows and heifers. Observed calves varied from an average low of 71 to a high of 1027 µg./100 ml. (168).

A general tendency for Shorthorns to have a higher carotene level was noted. The breed may be slightly more efficient in absorbing carotene and converting it to vitamin A (168).

The critical level of carotene in the plasma is about 25 micrograms per 100 ml., vitamin A about 16 micrograms per 100 ml. (65).

Blood Glucose and Acetone Bodies of Cows (166)

Item	Mg./100 ml. Blood
Normal - before parturition	
Blood glucose	47
Blood acetone bodies	2.7
Normal - postpartum	
Blood glucose	41
Acetone bodies	6.3

Blood Constituents of Cows (Low and High for the Year)(191)

Phosphorus, mg./100 ml. plasma	3.28 - 4.49
Hemoglobin, gm./100 ml. blood	10.8 - 12.1
Plasma protein, gm./100 ml.	8.3 - 9.0
Red blood cells, millions/cu. mm.	6.25 - 7.07

Blood Phosphorus for Dry Cows on the Range (146)

Month	Inorganic P mg./100 cc. Plasma
April	2.14 - 3.19
May	2.58 - 7.10
June	2.60 - 6.62
July	4.29 - 5.10
August	3.82 - 5.75
September	3.70 - 4.50
October	3.70 - 4.10
Average	4.03

The optimum phosphorus level for range cows is about 4 mg. inorganic phosphorus per 100 cc. whole blood (32)(243).

Potassium and Calcium Values, Normal Animals (69)

Plasma K, mg./100 cc.	14.50 - 16.2
Serum Ca, mg./100 cc.	10.6 - 11.9
Ratio, K:Ca	1:35 - 1:53

Blood Constituents, Normal Animals (81)

Glucose, mg./100 cc. blood serum	71.3 - 75.7
Ca, mg./100 cc. blood serum	10.58 - 11.20
Mg, mg./100 cc. blood serum	1.84 - 2.03
Fe, mg./100 cc. blood serum	33.6 - 35.6
K, mg./100 cc. blood serum	15.1 - 17.2

Plasma ascorbic acid values fell generally between 50 and 300 mg. percent and were unrelated to any obvious dietary, environmental, age, or breed differences (168).

Plasma Constituents of Normal, Spayed and Cows with Symptoms of Nymphomania (248)

Plasma Constituents

	Normals	Spayed	Nymphomania
Hemoglobin, gm. %	11.35	11.85	11.40
Plasma calcium, mg. %	9.3	10.3	9.5
Plasma inorganic phosphorus, mg. %	6.34	6.03	4.56
Plasma protein, gm. %	7.98-8.77	7.92-8.91	9.14-9.77

Partition of Plasma Proteins

	Normal	Nymphomania
Total plasma protein	7.61	9.23
Plasma albumin	3.05	2.81
Total globulin	4.56	6.40
Alpha globulin	.65	.73
Beta globulin	1.57	1.95
Gamma globulin	2.34	3.73

Cows: Phosphorus, mg./100 ml. plasma: Ranges from 3.1 - 5.9 during a year (187).

Potassium and sodium balance in bovine red cells (22).

Milliequivalents Per Liter of Red Cell or Plasma Water

Red Cells			Plasma		
K	Na	Cl	K	Na	Cl
35	104	85	5.1	150	109

Calcium varies from 10.0 to 12.2 mg. percent and does not appear to be correlated with season, breed, or age (168).

Blood Glutathione of Cows (205)

	Glutathione (mg. percent)		
	Reduced	Oxidized	Total
Cows	38.29	6.79	45.08

Normal tocopheral levels in the blood of cows are 500 to 685 micrograms per 100 ml. (124)(165).

Normal plasma values for 17-hydroxycorticosteroid ranged from 7.0 to 17.62 micrograms percent with a mean of 11.78 micrograms percent (215).

One mg. of tyrosine is contained in 19.78 mg. of the total protein of mixed bovine serum (86).

A linear relationship exists between the serum protein concentration and the serum specific gravity, provided the latter falls within the range 1.0220 to 1.0365.

Within these limits, $P = 362.0\ (G - 1.0220)$(86).
Specific gravity, adult cow (blood), 1.046 to 1.058; av. 1.052 (2).
Erythrocyte sedimentation rate, mm./hr. 1 to 1.8 (2).
Freezing point depression (0^o C) of serum is minus 0.585 (2).
Blood platelet count (thousands per cubic mm. blood) adult animals 542 to 975, av. 684 (2).
Packed RBC volume; ml./100 ml. blood 33 to 47, av. 40 (2).
Blood hemoglobin concentration, gm./100 ml. blood; 8.7 to 14.5, av. 11.5 (2).
RBC hemoglobin concentration, gm./100 ml. blood; av. 29 (2).
Erythrocyte diameter, dry, 5.9 (2).
Blood erythrocyte value, adult female, 6.0 to 7.8 av. 8.05 (2).
Hematocrit, adult female, ml./100 ml. blood, 31 to 54, av. 38.6 (2).
Blood hemoglobin concentration, adult female, gm./100 ml. blood, 9.2 to 18.3, av. 12.9 (2).
Corpuscle hemoglobin content, adult female, μμg; 14.2 to 18.5 av. 15.7 (2).
Corpuscle value (μ^3) adult female; 47 to 54, av. 50 (2).
Leukocytes, thousands/$mm.^3$ blood; 5 to 12 (2).
Number/$mm.^3$ blood, of (2):

Neutrophils	1,200 - 4,800
Eosinophils	180 - 1,800
Basophils	0 - 100
Lymphocytes	2,700 - 6,900
Monocytes	150 - 1,800

Blood water and solids (2):

Water: gm./100 ml.

Blood	85
RBC	64
Plasma	91

Solids: gm./100 ml.

Blood	20
RBC	44
Serum	9

Blood carbohydrates and related substances (2):

Glucose: mg./100 ml.

Blood	36 to 57, average 46
RBC	15
Serum	85

Adenosine triphosphate: mg./100 ml. RBC 27

Blood lipids (2):

Lipid: mg./100 ml.

Total lipid, 185 to 511, average 348 (plasma)
Neutral fat, 0 to 230, average 105 (plasma)
Phospholipid, 17 to 151, average 84 (plasma)
Phospholipid, 80 (serum)
Lecithin, 54 (serum)
Aphalin, 3 (serum)
Sphingomgelin, 22 (serum)
Cholesterol, 8 to 212, average 110 (plasma)
Cholesterol, free, 0 to 85, average 37 (plasma)
Cholesterol, esterfied, 25 to 121, average 73 (plasma)
Cholesterol esters, 42 to 204, average 123 (plasma)
Fatty acids, total, 26 to 378, average 202 (plasma)

Plasma proteins (2):

	gm./100 ml.
Plasma protein, total	7.4 to 10.2, average 8.32
Fibrinogen	0.72
Serum protein, total	7.60
Albumin	3.63
Globulin	3.97

Tryptophane: mg./100 ml. plasma, 0.8 to 1.2, average 1.1 (2)

Phosphorus values (2):

Phosphorus, inorganic: mg./100 ml. blood; 4.9 to 7.2, average 5.8
Phosphorus, organic, acid-soluble: mg./100 ml. blood; average 3.6
Phosphorus, organic, acid-soluble: mg./100 ml. RBC; average 9.1
Adenosine triphosphate phosphorus:
mg./100 ml. blood; 2.1
mg./100 ml. RBC; 5.1
Diphosphoglycerate phosphorus:
mg./100 ml. blood; less than 0.3
mg./100 ml. RBC; less than 0.6
Nucleotide phosphorus:
mg./100 ml. blood; 0.8
mg./100 ml. RBC; 2.0

Sulfur values (2):

Inorganic: mg./100 ml. RBC; 1.45
Conjugated: mg./100 ml. RBC; 0.21

Copper: µg./100 ml. blood, 820 to 1400 (2):

Glutathione values (mg./100 ml.)(2):
Total glutathione:
Blood; 46
RBC; 181
Plasma; 0.0

Glutathione reduced:
Blood; 40
RBC; 157
Plasma; 0.0

Glutathione oxidized:
Blood; 6
RBC; 24
Plasma; 0.0

Estrogen as estradiol: µg./100 ml. (2):
Blood; 0.3
Plasma; 0.25

Pregnant cow:
Blood; 0.38
RBC; 0.2
Plasma; 0.1

Blood enzyme activity (2):
(activity per 100 ml.)
Carbonic anhydrase; 80,000 to 140,000 (RBC) Catalose; 81,600 to 469,200 (blood)
Cholenesterase (substrate, acetylcholine); 45 (serum)
Cholenesterose (Substrate acetylbetamethylcholine): 211 (RBC)

Vitamin Values (2)

	100 ml. Blood		100 ml. Plasma	
	Value	Range	Value	Range
Blood vitamins				
A as carotenal	14 µg.	6 - 18 µg.	24 µg.	10 - 30 µg.
A as carotene	40 µg.	25 - 950 µg.	70 µg.	50 - 2000 µg.
Ascorbic acid	0.5 mg.	0.2 - 1.5 mg.	0.5 mg.	0.2 - 1.5 mg.
Vitamin B_{12}	0.05 µg.	0.04 - 0.05 µg.		
Choline, total		11 - 31 mg.	16.5 mg.	
Choline, free			4 mg.	
D^3 as calciferol			6.8 µg.	
E as tocopherol			0.40 mg.	0.20 - 0.50 mg.
Nicotinic acid	0.3 mg.			
Pteroylglutamic acid				
Total		2.1 - 3.0 µg.		1.8 - 2.2 µg.
Free	0.19 µg.	0.06 - 0.45 µg.	0.05 µg.	
Riboflavin	45 µg.	40 - 50 µg.		
Thiamine	8 µg.	5 - 11 µg.		

In a study of the influence of temperature on blood composition of cattle, the environmental temperature remained constant one to two weeks before changing to another temperature (34). The following results were noted:

(a) No obvious changes occurred between 0° and 65° F., except possibly an increase in the glucose level at the lower temperature.

(b) On raising the temperature from 65° to 100° F., creatinine increased 100 percent; carbon dioxide-combining capacity, ascorbic acid, cholesterol, were all reduced to less than half the level at 50° F.

(c) There were no apparent disturbances in water, electrolyte and colloid concentration on increasing environmental temperature from 65° to 100° F.

(d) The trends in plasma protein-bound iodine with changing temperature were too uncertain to permit interpretations in their bearing on thyroid activity.

(e) There were no striking blood composition differences between Brahman and British cows in their response to changing temperature.

TABLE XXXIII

Comparative Composition of Blood Plasma and Milk of the Cow (175)

Blood Plasma		Milk	
Composition	Percent	Composition	Percent
Water	91.00	Water	87.0
Glucose	0.05	Lactose	4.90
Serum albumin	3.20	Lactalbumin	0.52
Serum globulin	4.40	Lactoglobulin	0.05
Amino acids	0.003	Casein	2.90
Neutral fat	0.06	Neutral fat	3.70
Phospholipids	0.24	Phospholipids	0.04
Cholesterol ester	0.17	Cholesterol ester	trace
Calcium	0.009	Calcium	0.12
Phosphorus	0.011	Phosphorus	0.10
Sodium	0.34	Sodium	0.05
Potassium	0.03	Potassium	0.15
Chlorine	0.35	Chlorine	0.11
Citric acid	trace	Citric acid	0.20

TABLE XXXIV

Percentage Composition of Milk of Different Species (175)

Species	Water	Protein	Fat	Lactose	Ash	Calcium	Phosphorus	Calories
Cow	87.2	3.5	3.7	4.9	0.72	0.121	0.095	74
Sheep	82.7	5.5	6.4	4.7	0.92	0.201	0.168	109
Goat	86.5	3.6	4.0	5.1	0.81	0.131	0.104	49
Mare	89.0	2.7	1.6	6.1	0.51	-	-	54
Sow	82.0	6.2	6.8	-	0.96	0.252	0.151	113
Woman	87.5	1.0	4.4	7.0	0.21	0.035	0.013	70
Bitch	75.4	11.2	9.6	3.1	0.73	-	-	163

Folic Acid and Vitamin B_{12} Content of Bovine Milk (63)

	Micrograms Per Liter	
90-150 days postpartum	Vitamin B_{12}	Folic Acid
Mean	6.6	1.3
Range	3.2-12.4	0.20-4.0

B_{12} higher than in any other species studied.

The ascorbic acid value of cow's milk ranges from 15.4 to 18.4 mg. per liter (117).

Vitamin Content of Colostrum of Milk of the Cow (195)

Vitamin	Micrograms per ml. Colostrum	Milk
Thiamine	0.62	0.38
Riboflavin	6.10	1.77
Nicotinic acid	0.96	0.91
Pantothenic acid	2.24	3.67

Days after Parturition	Micrograms per ml. Thiamine	Riboflavin	Pantothenic Acid
0	0.58	5.69	1.73
1	0.59	3.53	3.20
2	0.59	2.67	3.96
3	0.59	2.32	4.24
4	0.58	2.03	4.01
5	0.59	2.03	4.05
6	0.58	1.93	4.19
7	0.57	1.87	4.29
8	0.56	1.87	4.38
9	0.56	1.89	4.16
30	0.38	1.83	3.82

Some Vitamin and Trace Elements Found in the Colostrum of the Beef Cow (169)

Item	Value
No. samples	6
Fe (mg./kg.)	1.80 (1.30-2.50)
Cu (mg./kg.)	0.40 (0.30-0.60)
Co (mg./kg.)	0.006 (0.004-0.011)
Carotene (g./100 ml.)	129 (70-233)
Vitamin A (g./100 ml.)	145 (54-225)
Thiamine (g./ml.)	0.85 (0.64-1.00)
Riboflavin (g./ml.)	4.98 (3.22-6.75)
Pantothenic acid (g./ml.)	1.71 (0.69-3.20)
Nicotinic acid (g./ml.)	0.57 (9.43-0.61)

Milk Vitamin A Values from Cows on Inadequate and Adequate Vitamin A Rations (16)

	Vitamin A (µg./100 ml.) Deficient Ration	Adequate Ration
Milk, at calving	45.56	90.56
Milk, 2-week lactation	4.9	7.7
Milk, 3-month lactation	2.8	4.5

Angus cows had higher carotene and vitamin A than colostrum from Shorthorn or Herefords (169).

Distribution of Carotenoids in the Tissues of the Cow (85)

	Liver µg./gm.	Ovaries µg./gm.
Carotenes	20.6 (12.0-32.6)	112.8 (8.5-28.5)
Xanthophylls	1.2 (0.8-1.3)	3.1 (0.9-7.2)

Relationship of Maternal and Fetal Vitamin A Content (41)

Normal Intake		Restricted Intake	
Liver of dam (I.U./gm.)	Liver of Fetus (I.U./gm.)	Liver of Dam (I.U./gm.)	Liver of Fetus (I.U./gm.)
224.7	6.2	120.8	2.7
175.8	6.1	94.0	0.0

Composition of Bovine Saliva (3)

Specific gravity	1.008
pH	8.8
Mucin	0.0
Ptyalin	0.0
Water	99.15 percent
Organic matter	0.17 percent
Inorganic matter	0.68 percent
Na	0.2768 percent
Mg	0.006 percent
Chlorides	0.0154 percent
Sulphates	0.0145 percent
Phosphates	0.359 percent

Composition of Amniotic Fluid and Placenta of the Bovine (73)

	Amniotic Fluid	Placenta
Weight (pounds)	32.7	18.3
Water (percent)	95.9	85.6
Fat (percent)	0.92	0.92
Protein (percent)	3.36	12.20
Ash (percent)	0.65	0.89

The pH of the amniotic fluid varies from 7.0 to 7.4 with an average value of 9.12 (163).

Composition of Horn of Cow (5)

Carbon	51.03 percent
Hydrogen	6.80 percent
Nitrogen	16.24 percent
Oxygen	22.51 percent
Sulphur	3.42 percent

The Mineral Content of Cattle Hair (241)

Color	Ash Content
Black	2.29 percent
White	1.63 percent
Brown	1.48 percent
Red	1.71 percent

Melanin	Ash Content
White hair	1.63 percent
Black hair	11.83 percent
Nitrogen	13.4-14.4 percent
Na	1.69 percent
K	2.18 percent

Also found Mg, P, Mn, Fe, Cn, Ag, Ca, Pb, Zn, Na, and K.

Micturition (234)

Micturition can be induced by a gentle massage starting below the ventral cominissure of the vulva and taking its course upward and laterally, terminating beside the labium vulva.

Urine Volume per 24 Hours (cc.) 2500 to 9500, Average 5400

Breed	Average Values, 24-hour Period Volume (cc.)	Wt. (lbs.)
Hereford	5,454	12.3
Shorthorn	5,310	11.9
Angus	5,189	11.7

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